ASAE D384.1 FEB03
Manure Production and Characteristics

American Society of Agricultural Engineers

STANDARD

ASAE is a professional and technical organization, of members worldwide, who are dedicated to advancement of engineering applicable to agricultural, food, and biological systems. ASAE Standards are consensus documents developed and adopted by the American Society of Agricultural Engineers to meet standardization needs within the scope of the Society; principally agricultural field equipment, farmstead equipment, structures, soil and water resource management, turf and landscape equipment, forest engineering, food and process engineering, electric power applications, plant and animal environment, and waste management.

NOTE: ASAE Standards, Engineering Practices, and Data are informational and advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. The ASAE assumes no responsibility for results attributable to the application of these ASAE Standards, Engineering Practices, and Data. Conformity does not ensure compliance with applicable ordinances, laws and regulations. Prospective users are responsible for protecting themselves against liability for infringement of patents.

This standard may be designated ANSI/ASAE. If so, this standard is an American National Standard. Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.
Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

CAUTION NOTICE: In the case that this standard is an ANSI/ASAE standard, this American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

ASAE-The Society for engineering in agricultural, food, and biological systems
2950 Niles Rd., St. Joseph, MI 49085-9659, USA ph. 269-429-0300, fax 269-429-3852, hq@asae.org

Manure Production and Characteristics

Developed by the Engineering Practices Subcommittee of the ASAE Agricultural Sanitation and Waste Management Committee; approved by the Structures and Environment Division Standards Committee; adopted by ASAE December 1976: reconfirmed December 1981, December 1982, December 1983, December 1984, December 1985, December 1986, December 1987: revised June 1988; revised editorially and reaffirmed December 1993; revised editorially March 1995; reaffirmed December 1998, December 1999, December 2001, reaffirmed for one year February 2003.

1 Purpose and scope

1.1 Data on livestock manure production and characteristics are presented to assist in the planning, design and operation of manure collection, storage, pretreatment and utilization systems for livestock enterprises.

1.2 These data are combined from a wide base of published and unpublished information on livestock manure production and characterization. Users of this information should recognize that the mean values for each parameter are determined by an arithmetic average consisting of one data point per reference source per year. The values represent fresh (as voided) feces and urine. Actual values vary due to differences in animal diet, age, usage, productivity and management. Whenever site specific data are available or actual sample analyses can be performed, such information should be considered in lieu of the mean values presented here.

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure‡	kg	mean§	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	kg	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	kg/m³	mean	990	1 000	1 000	990	1 000	1 000	1 000	970	1 000	1 000	**
		std. deviation	63	75	**	24	64	**	93	39	**	**	**
Total solids	kg	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	kg	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	kg	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	kg	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	3.7	2.5	**	**	2.7	1.8	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen‖	kg	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	kg	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	kg	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21
Orthophosphorus	kg	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.005 8	**	**	**	0.014	**	0.007 1	0.016	**	**	**
Potassium	kg	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	kg	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	kg	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.007 1	**
Sulfur	kg	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.005 2	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	kg	mean	0.052	0.030	0.086	0.067	0.078	**	0.038	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	kg	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	g	mean	12	7.8	0.33	16	8.1	**	16	60	**	75	**
		std. deviation	6.6	5.9	**	9.7	3.2	**	8.1	49	**	28	**
Manganese	g	mean	1.9	1.2	**	1.9	1.4	**	2.8	6.1	**	2.4	**
		std. deviation	0.75	0.51	**	0.74	1.5	**	2.1	2.2	**	0.33	**

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day (continued)

Parameter	Units*		Animal Type†									
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Boron	g	mean	0.71	0.88	**	3.1	0.61	**	1.2	1.8	**	**	**
		std. deviation	0.35	0.064	**	0.95	0.30	**	0.48	1.7	**	**	**
Molybdenum	g	mean	0.074	0.042	**	0.028	0.25	**	0.083	0.30	**	**	**
		std. deviation	0.012	**	**	0.030	0.38	**	0.033	0.057	**	**	**
Zinc	g	mean	1.8	1.1	13	5.0	1.6	**	2.2	19	3.6	15	**
		std. deviation	0.65	0.43	**	2.5	1.0	**	2.1	33	**	12	**
Copper	g	mean	0.45	0.31	0.048	1.2	0.22	**	0.53	0.83	0.98	0.71	**
		std. deviation	0.14	0.12	**	0.84	0.068	**	0.39	0.84	**	0.10	**
Cadmium	g	mean	0.003 0	**	**	0.027	0.007 2	**	0.005 1	0.038	**	**	**
		std. deviation	**	**	**	0.028	**	**	**	0.032	**	**	**
Nickel	g	mean	0.28	**	**	**	**	**	0.62	0.25	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	g	mean	**	**	**	0.084	0.084	**	**	0.74	**	**	**
		std. deviation	**	**	**	0.012	**	**	**	**	**	**	**
Total coliform bacteria	colonies‡	mean	1 100	63	**	45	20	**	490	110	**	**	**
		std. deviation	2 800	59	**	33	26	**	490	100	**	**	**
Fecal coliform bacteria	colonies	mean	16	28	**	18	45	**	0.092	7.5	**	1.4	180
		std. deviation	28	27	**	12	27	**	0.029	2.0	**	**	180
Fecal *streptococcus* bacteria	colonies	mean	92	31	**	530	62	**	58	16	**	**	590
		std. deviation	140	45	**	290	73	**	59	7.2	**	**	**

*All values wet basis.
†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 640 kg; beef, 360 kg; veal, 91 kg; swine, 61 kg; sheep, 27 kg; goat, 64 kg; horse, 450 kg; layer, 1.8 kg; broiler, 0.9 kg; turkey, 6.8 kg; and duck, 1.4 kg.
‡Feces and urine as voided.
§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.
‖All nutrients and metals values are given in elemental form.
#Mean bacteria colonies per 1 000 kg animal mass multiplied by 10^{10}. Colonies per 1 000 kg animal mass divided by kg total manure per 1 000 kg animal mass multiplied by density kg/m^3 equals colonies per m^3 of manure.
**Data not found.

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day

Parameter	Units*		Animal Type†									
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure‡	lb	mean§	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	lb	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	lb/ft^3	mean	62	63	62	62	64	63	63	60	63	63	**
		std. deviation	4.0	4.7	**	1.5	4.0	**	5.8	2.4	**	**	**
Total solids	lb	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	lb	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	lb	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	lb	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	5.3	2.5	**	**	2.7	18	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen‖	lb	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	lb	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	lb	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day (continued)

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Orthophosphorus	lb	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.058	**	**	**	0.014	**	0.0071	0.016	**	**	**
Potassium	lb	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	lb	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	lb	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.0071	**
Sulfur	lb	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.0052	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	lb	mean	0.052	0.030	0.086	0.067	0.078	**	0.036	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	lb	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	lb	mean	0.012	0.0078	0.00033	0.016	0.0081	**	0.016	0.060	**	0.075	**
		std. deviation	0.0066	0.0059	**	0.0097	0.0032	**	0.0081	0.049	**	0.028	**
Manganese	lb	mean	0.0019	0.0012	**	0.0019	0.0014	**	0.0028	0.0061	**	0.0024	**
		std. deviation	0.00075	0.00051	**	0.00074	0.0015	**	0.0021	0.0022	**	0.00033	**
Boron	lb	mean	0.00071	0.00088	**	0.0031	0.00061	**	0.0012	0.0018	**	**	**
		std. deviation	0.00035	0.000064	**	0.00095	0.00030	**	0.00048	0.0017	**	**	**
Molybdenum	lb	mean	0.000074	0.000042	**	0.000028	0.00025	**	0.000083	0.00030	**	**	**
		std. deviation	0.000012	**	**	0.000030	0.00038	**	0.000033	0.000057	**	**	**
Zinc	lb	mean	0.0018	0.0011	0.013	0.0050	0.0016	**	0.0022	0.019	0.0036	0.015	**
		std. deviation	0.00065	0.00043	**	0.0025	0.0010	**	0.0021	0.033	**	0.012	**
Copper	lb	mean	0.00045	0.00031	0.000048	0.0012	0.00022	**	0.00053	0.00083	0.00098	0.00071	**
		std. deviation	0.00014	0.00012	**	0.00084	0.000066	**	0.00039	0.00084	**	0.00010	**
Cadmium	lb	mean	0.0000030	**	**	0.000027	0.0000072	**	0.0000051	0.000038	**	**	**
		std. deviation	**	**	**	0.000028	**	**	**	0.000032	**	**	**
Nickel	lb	mean	0.00028	**	**	**	**	**	0.00062	0.00025	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	lb	mean	**	**	**	0.000084	0.000084	**	**	0.00074	**	**	**
		std. deviation	**	**	**	0.000012	**	**	**	**	**	**	**
Total coliform bacteria	colonies‡	mean	500	29	**	21	9.0	**	220	50	**	**	**
		std. deviation	1300	27	**	15	12	**	220	46	**	**	**
Fecal coliform bacteria	colonies	mean	7.2	13	**	8.0	20	**	0.042	3.4	**	0.62	81
		std. deviation	13	12	**	5.4	12	**	0.013	0.91	**	**	81
Fecal streptococcus bacteria	colonies	mean	42	14	**	240	28	**	26	7.4	**	**	270
		std. deviation	63	21	**	130	33	**	27	3.3	**	**	**

*All values wet basis.
†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 1400 lb; beef, 800 lb; veal, 200 lb; swine, 135 lb; sheep, 60 lb; goat, 140 lb; horse, 1000 lb; layer, 4 lb; broiler, 2 lb; turkey, 15 lb; and duck, 3 lb.
‡Feces and urine as voided.
§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.
¶All nutrients and metals values are given in elemental form.
#Mean bacteria colonies per 1,000 lb animal mass multiplied by 10^{10}. Colonies per 1,000 lb animal mass divided by lb total manure per 1,000 lb animal mass multiplied by density (lb/ft^3) equals colonies per ft^3 of manure.
**Data not found.